

## ADJUSTABLE DAMPER WITH VALVE MOUNTED IN-LINE

### FIELD OF THE INVENTION

**[0001]** The present invention relates generally to an adjustable damper, and more particularly, to an adjustable damper with a valve mounted in-line.

### BACKGROUND OF THE INVENTION

**[0002]** Conventionally, adjustable dampers are used on shock absorbers to adjust the damping resistance dependent upon specific external conditions. Conventional shock absorbers operate by metering the flow of fluid between chambers. Typically, shock absorbers have a central chamber with a valve slideably positioned therein. The valve is attached to the sprung mass while the cylinder, itself, is attached to the un-sprung mass (such as the vehicle wheels). Movement of the un-sprung mass moves the valve which causes fluid to move from one side of the cylinder to the other. In addition, a reserve chamber is provided for additional fluid flow. In the adjustable damper, an adjustable valve is positioned between the central tube and the reserve tube. As the adjustable valve is relatively complex in construction, especially when compared to fixed resistance valves, they require a large amount of room for mounting. Moreover, a prime location for these valves tends to be half way along the length of the damper, as they usually regulate the flow through a down tube and into the reserve tube. As such, the conventional adjustable valve typically extends radially from the central axis of the tube and regulates fluid flow between the central chamber and the reserve tube.

[0003] While this arrangement does act to provide an adjustable damper, drawbacks exist. Specifically, as the adjustable damper valve extends radially outward from the shock absorber, it can interfere with the surrounding structure of the vehicle. Moreover, this radial extension creates additional manufacturing requirements, costs and difficulties. The present invention was developed in light of these and other drawbacks.

#### SUMMARY OF THE INVENTION

[0004] To address these and other drawbacks, the present invention provides an adjustable valve located in line with or covered by the outer tube. Accordingly, the present invention provides an inner cylinder positioned inside an outer cylinder to define a reserve chamber. A rod is positioned within the inner cylinder and has a valve attached thereto. The area above the valve is defined as an upper working chamber while the area below the valve is defined as a lower working chamber. An adjustable valve portion is supported in a lower support, which is in turn supported by the inside wall of the outer cylinder. The adjustable valve portion regulates fluid flow from the upper working chamber to the reserve chamber. Also, by virtue of supporting the adjustable valve portion by the inside walls of the outer cylinder, the adjustable valve portion can be positioned in-line and as one unit with the entire damper.

In another aspect, the inner cylinder comprises a first inner cylinder and a second inner cylinder spaced apart by a gap. The gap feeds fluid from the upper working chamber of the inner cylinder into the adjustable valve for regulation into the reserve chamber.

**[0005]** Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0006]** The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

**[0007]** Fig. 1 is a cross-sectional view of an adjustable damper with valve mounted in-line according to a first embodiment of the present invention;

**[0008]** Fig. 2 is a cross-sectional view of an adjustable damper with valve mounted in-line according to a second embodiment of the present invention;

**[0009]** Fig. 3 is a schematic view of a vehicle using an adjustable damper with valve mounted in-line according to the present invention;

**[0010]** Fig. 4 is a cross-sectional view showing the operation of an adjustable damper with valve mounted in-line according to the first embodiment of the present invention;

**[0011]** Fig. 5 is a cross-sectional view showing the operation of an adjustable damper with valve mounted in-line according to the first embodiment of the present invention;

**[0012]** Fig. 6 is a cross-sectional view showing the operation of an adjustable damper with valve mounted in-line according to the second embodiment of the present invention; and

**[0013]** Fig. 7 is a cross-sectional view showing the operation of an adjustable damper with valve mounted in-line according to the second embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0014]** The following description of the preferred embodiments is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

**[0015]** Referring now to Fig. 1, a first embodiment of the present invention is shown and described. In Fig. 1, a damper 10 includes a fluid movement portion 12 and an adjustable valve 14.

**[0016]** Fluid movement portion 12 includes an inner cylinder 16 and an outer cylinder 18. Preferably, inner cylinder 16 and outer cylinder 18 are coaxially aligned, such that the central axis of the inner cylinder 16 is the same as the that of outer cylinder 18. An upper rod guide 20 and a lower support 22 maintain inner cylinder 16 and outer cylinder 18 in position. Upper rod guide 20 slidingly supports a rod 24 such that rod 24 can slide up and down within inner cylinder 16. At one end of rod 24 is a valve 26. Valve 26 allows fluid to pass through at a resistance desired to properly damp vibrations. An upper working chamber 28 is defined by an area between valve 26, inner cylinder 16, and upper rod guide 20. Likewise, a lower

working chamber 30 is defined by inside inner cylinder 16 on a side of valve 26 opposite to upper rod guide 20. A down tube 32 connects upper working chamber 28 with a reserve chamber 34

**[0017]** Reserve chamber 34 is defined by the space between outer cylinder 18 and inner cylinder 16. Reserve chamber 34 serves to compensate for the difference in volume between upper working chamber 28 and lower working chamber 30 by virtue of rod 24. Down tube 32 is a cylindrical tube that extends from a passage 36 to a valve entrance 38.

**[0018]** Adjustable valve 14 includes lower support 22, an end cap 40 and an adjustable valve portion 42. Lower support 22 clamps the outer periphery of adjustable valve portion 42 to maintain adjustable valve portion 42 in axial alignment with rod 24, inner cylinder 16 and outer cylinder 18. Likewise, end cap 40 slides inside outer cylinder 18 and presses against lower support 22 to seal adjustable valve portion 42 therein. Preferably, adjustable valve portion 42 is maintained within outer cylinder 18. This serves to protect the valve from the external environment and the possibility of being damaged by external elements. Moreover, adjustable valve portion 42 is preferably cylindrical, having an axis that is aligned with that of inner cylinder 16 and outer cylinder 18. This allows the overall device to be streamlined and more compact.

**[0019]** Valve entrance 38 communicates with a valve entrance 44 and a valve exit 46 communicates with reserve chamber 34 through a passage 48. As is understood, adjustable valve portion 42 regulates flow resistance from fluid traveling from valve entrance 38, through adjustable valve portion 42 and into passage 48.

This regulation can be responsive to driver requirements, vehicle CPU requirements, or any other requested input.

**[0020]** Referring now to Figs. 4 and 5, the operation of the present invention is shown and described. In Fig. 4, an extension stroke is illustrated where rod 24 is being moved outward and away from adjustable valve 14. Here, valve 26 is designed to allow a small amount of fluid to flow from upper working chamber 28 to lower working chamber 30 at low piston speeds. As a result, the majority of fluid is pumped from upper working chamber 28, through passage 36 and into down tube 32. From here, fluid is passed from down tube 32, through valve entrance 38 and into adjustable valve portion 42. Adjustable valve portion 42 then regulates the flow of fluid into passage 48 and into reserve chamber 34. Likewise, in Fig. 5, a compression stroke is illustrated where valve 26 is moved toward adjustable valve portion 42. Valve 26 allows fluid to flow from lower working chamber 30, through valve 26 and into upper working chamber 28. From here, due to the rod volume effect, fluid flows from upper working chamber 28, through passage 36 and into down tube 32. Fluid then flows into valve entrance 38, through adjustable valve portion 42 into passage 48 and into reserve chamber 34.

**[0021]** Referring now to Fig. 2, a second embodiment of the present invention is shown and described. In Fig. 2, a first inner cylinder 16a and a second inner cylinder 16b are concentrically disposed to separate upper working chamber 28 and lower working chamber 30 from reserve chamber 34. Moreover, first inner cylinder 16a and second inner cylinder 16b are spaced slightly apart to provide a gap 16c. An aperture 50 fluidly connects upper working chamber 28 with gap 16c.

**[0022]** Adjustable valve 14 includes adjustable valve portion 42, lower support 22, and end cap 40. A seal 52 ensures that leakage does not occur between end cap 40 and lower support 22.

**[0023]** In lower support 22, a plurality of passages are provided therein to allow fluid flow between the reserve chamber and the upper and lower working chambers. Specifically, passage 48 connects reserve chamber 34 and adjustable valve portion 42, valve entrance area 38 connects valve entrance 44 and gap 16c, and a passage 54 connects lower working chamber 30 with reserve chamber 34.

**[0024]** A series of valves ensures that fluid moves throughout the entire damper 10 in certain directions under certain resistances. Specifically, a valve 56 is a leaf-like valve that allows fluid flow only in a direction from reserve chamber 34 to lower working chamber 30. Valve 26 allows fluid flow from lower working chamber 30 to upper working chamber 28. Adjustable valve portion 42 regulates fluid flow from valve entrance area 38 to passage 48. This regulation is dependent upon feedback from a vehicle driver, vehicle central processing unit, or other type of feedback device. By way of a non-limiting example, adjustable valve 42 can adjust the fluid resistance therethrough based on an external signal from an air spring. The adjustable valve portion then adjusts the flow resistance to obtain the best flow resistance to obtain the best damping characteristics for the given pressure in the air springs. As adjustable valves are complicated in construction, when compared to fixed resistance valves, they tend to be large. Therefore, they have traditionally been required to be positioned external to the outer cylinder, as the area inside the damper has been typically unable to support the adjustable valve portion.

**[0025]** Referring now to Fig. 6 and Fig. 7, the operation of the second embodiment of the present invention is described. In Fig. 6, a compression stroke is illustrated where rod 24 is shown being moved toward adjustable valve portion 42. This compression causes fluid in lower working chamber 30 to travel through valve 26 and into upper working chamber 28. As the volume of lower working chamber 30 does not include rod 24, the rod volume effect causes excess fluid to flow into upper working chamber 28. Therefore, the excess fluid is forced from upper working chamber 28, through aperture 50 and into gap 16c. From here, fluid flows from gap 16c, through valve entrance area 38 and into adjustable valve portion 42. Next, fluid flows from adjustable valve portion 42 into reserve chamber 34. In Fig. 7, an extension stroke is illustrated where rod 24 is moved in a direction away from adjustable valve portion 42. Here valve 26 is designed to allow a small amount of fluid to flow from upper working chamber 28 to lower working chamber 30 at low piston speeds. As a result, the majority of fluid comes from reserve chamber 34, through passage 54, through valve 56 into lower working chamber 30.

**[0026]** Referring now to Fig. 3, damper 10 is shown used on a vehicle. Here, a sprung mass (vehicle body) 62 is connected to an un-sprung mass (wheel) 64. Specifically, rod 24 attaches to vehicle body 62 and outer cylinder 18 attaches to wheel 64. As a result, up and down movements of wheel 64 cause rod 24 to move with respect to outer cylinder 18, thereby moving fluid as described above to absorb vibration.

**[0027]** The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be

within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.